AIR FORCE

QUALIFICATION TRAINING PACKAGE (AFQTP)

for

HVAC/REFRIGERATION

(3E1X1)

MODULE 15

AIR AND HYDRONIC SYSTEMS

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MODULE 15

HVAC SYSTEMS

Career Field Education and Training Plan (CFETP) references from 1 Apr 97 version.

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INTRODUCTION

Before starting this AFQTP, refer to and read the "Trainee/Trainer Guide" located on the AFCESA Web site **http://www.afcesa.af.mil/**

AFQTPs are mandatory and must be completed to fulfill task knowledge requirements on core and diamond tasks for upgrade training. ***It is important for the trainer and trainee to understand*** that an AFQTP ***does not*** replace hands-on training, nor will completion of an AFQTP meet the requirement for core task certification. AFQTPs will be used in conjunction with applicable technical references and hands-on training.

AFQTPs and Certification and Testing (CerTest) must be used as minimum upgrade requirements for Diamond tasks.

MANDATORY minimum upgrade requirements:

Core task:
AFQTP completion
Hands-on certification

Diamond task:
AFQTP completion
CerTest completion (80% minimum to pass)

Note: *Trainees will receive hands-on certification training for Diamond Tasks when equipment becomes available either at home station or at a TDY location*.

Put this package to use. Subject matter experts, under the direction and guidance of HQ AFCESA/CEOF, revised this AFQTP. If you have any recommendations for improving this document, please contact the HVAC/R Career Field Manager at the address below.

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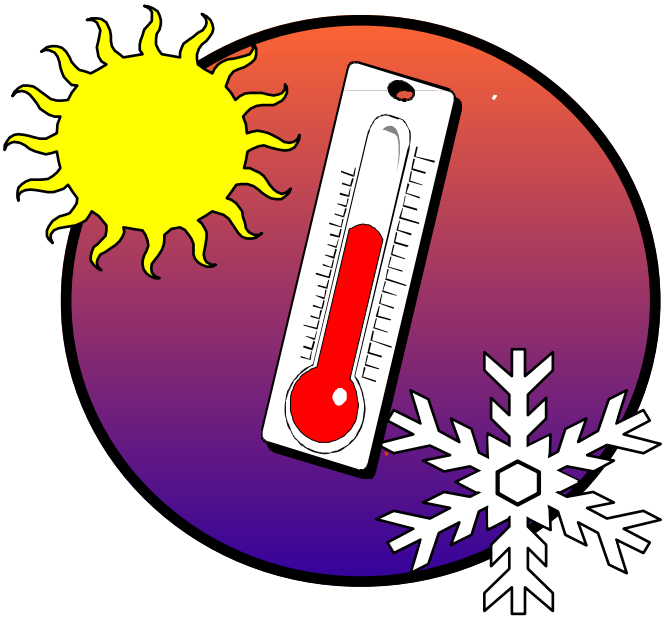
Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.



REPAIR HVAC SYSTEMS

MODULE 15 **AFQTP UNIT 10**

TROUBLESHOOT (15.10.1.)

CORRECT MALFUNCTION (15.10.2.)

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TROUBLESHOOT

CORRECT MALFUNCTION

Task Training Guide

STS Reference Number/Title:	15.10.1. Troubleshoot 15.10.2. Correct Malfunction
Training References:	• Modern Refrigeration Air conditioning; Trane Air conditioning Manual; ASHRAE Handbook,
Prerequisites:	• Possess as a minimum a 3E131 AFSC.
Equipment/Tools Required:	• Personal Protective Equipment • Standard HVAC tool bag
Learning Objective:	• Identify troubleshooting facts of HVAC systems
Samples of Behavior:	• Isolate and correct malfunctions in an HVAC system
Notes:	
• Any safety violation is an automatic failure.	

TROUBLESHOOT

CORRECT MALFUNCTION

Background: HVAC Systems: Heating, ventilating, and air conditioning units that are connected to air duct systems and distribute air to sizable areas are known as central station HVAC units. Central station units can be totally self-contained, with all heating and refrigeration system components as an integral part of an HVAC unit as are found in many large rooftop units, or they can be manufacturer-selected components. However, no matter how large the system capacity, all central HVAC units have some of the same basic components and characteristics.

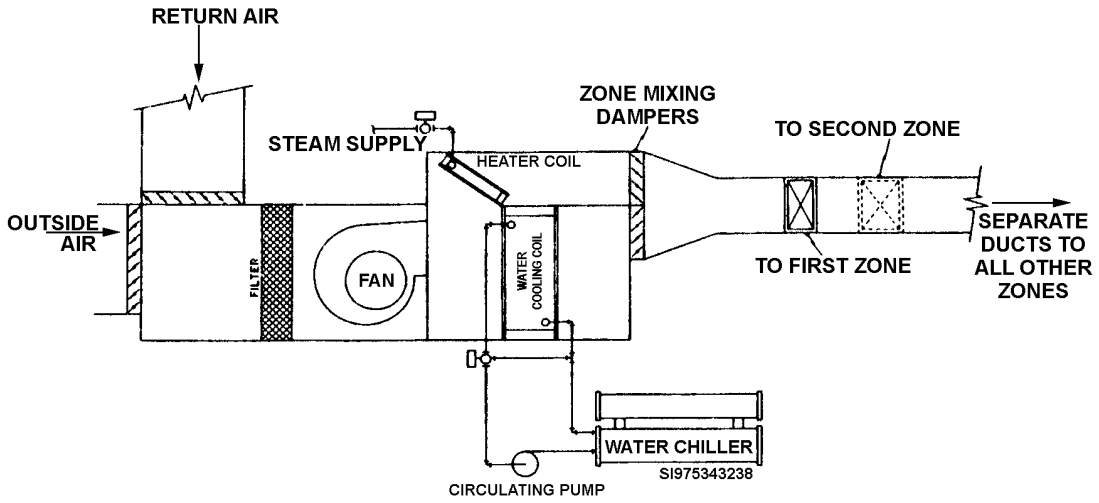
Basic central station. The basic central station system is an all-air, single-zone, heating, ventilating and air conditioning system. It may be designed as a low, medium, and high-pressure air distribution system.
Some applications of central systems are:

- Spaces with uniform loads
- Small spaces requiring precision control
- Multiple systems for large areas
- Systems for complete environmental control
- As a primary source of conditioned air for other systems

It is important that the fundamental values of the central system be kept in mind, that equipment is adequate, accessible for easy maintenance, and no more complex in arrangement and control than is necessary to produce the conditions required to meet the design criteria. In a central fan and single duct arrangement, with a single bank of direct expansion refrigerant coils for cooling, outside and return air are mixed, drawn through the cooling coil where the mixture is cooled and dehumidified, then into the fan which discharges it into the distributing ductwork. This arrangement has no provision for heating. It is the simplest design of a cooling and dehumidifying arrangement. It can vary in capacity from a small unit, which supplies a small space or a few rooms, to a large unit that supplies a large number of rooms or a large area. There are many variations that can be made to this arrangement without changing its characteristics, such as:

- Low velocity or high velocity ductwork can be employed for air distribution.
- A heating coil, using steam or hot water, can be added to furnish heat during winter operations.

A coil using cold water for cooling and another using hot water for heating can be substituted for the direct expansion refrigerant coil. To obtain better control on the central fan arrangements, bypass dampers, face and bypass dampers, split coils, zone reheat and multiple zone units have been employed. These are illustrated in Figure 1.



Courtesy of the National Environmental Balancing Bureau, from "Environmental Systems Technology"

Figure 1, System with central fan or fans, water cooling coil, steam heating coil, filters, mixing dampers for each zone, distributing, ductwork, refrigeration unit for chilling cold water, circulating pump and controls.

Terminal units. A terminal unit is a device or unit, often a box, that is located where the supply duct or duct branch terminates and the air is introduced into the space to be conditioned. There are a wide variety of terminal units. Some contain only air control dampers or valves, others may also have cooling or heating coils, and other variations, such as to regulate the quantity of air, or to regulate its temperature, or both.

The terminal unit performs several functions. First, it must supply air to a proper temperature to take care of the load in the conditioned space. This is done in response to a room thermostat located in the space. The unit also contains some type of device to regulate the airflow to the space. Pressure is reduced in the terminal unit to a level where the air can be introduced into the space. Any noise that is generated within the unit in the reduction of the pressure must be attenuated within the terminal unit.

Heating, ventilating, and air conditioning units that are connected to air duct systems that distribute air to sizable areas of a building are known as central station HVAC units. In the trade the name “central” usually means a unit that is built up on the job or a large capacity factory-built unit, which is connected to an extensive, supply air and return air duct distribution system.

Variable Air Volume. Variable air volume (VAV) systems are the most promising and versatile type of HVAC systems available today and the best concept ever in HVAC design. It’s a rapidly expanding approach that knows no limit in its application, and is restricted only by creativity, boldness, and past habits. VAV systems, in addition to helping solve the energy crisis by conserving energy in the area of 20 to 30% over conventional systems, equally reduces operational costs and first costs by using smaller equipment, fans, coils, refrigeration and heating equipment, ductwork, piping and insulation.

VAV systems also provide flexibility in zoning, comfort when designed properly, easy expansion, contraction, or rearrangement of the system, or partial shut down without affecting the central equipment to any degree. As with many HVAC systems, VAV systems have problems. The problems stem from the many new equipment and control performance requirements needed to control the constantly changing air volumes, when VAV systems are in operation, and the resultant effect on duct pressures, fan performance and air movement through terminals, outlets and in spaces.

Understanding VAV Systems. Most HVAC systems in the past, with certain exceptions, have been CONSTANT AIR volume, VARIABLE TEMPERATURE type systems. A residential or small commercial system is typically delivering a constant airflow, while the burner or air conditioner goes on and off changing the air temperatures to meet the load conditions. A VAV system is just the opposite. It delivers air at a CONSTANT TEMPERATURE while the air quantities are VARIED in the VAV box to satisfy changing space loads. As an average, VAV systems run at 70% of the peak load. Interior zones (zones inside a building located away from the outside walls) stay around 80% of maximum, +/-10%. Perimeter zones (zones inside a building located along the outside, or perimeter, walls) vary more extensively in the cooling cycle because of shifting sun loads.

Types of VAV Systems. Variable air volume systems are mostly cooling only systems, most frequently used in interior areas that only require cooling. They are also employed because of their zone control capabilities. One common approach in buildings is to have separate interior and perimeter systems, such as cooling only VAV systems for the interior, and a heating only (or heating cooling) system for the perimeter. The perimeter systems may be low-pressure constant air volume, baseboard radiation, cabinet heaters, or induction systems. VAV systems requiring full heating and cooling flexibility in interior and exterior zones can integrate a reheat coil in or near the VAV box. These units are set to maintain a predetermined minimum-throttling ratio necessary to offset the heating load. There are two basic methods used in VAV systems: the by-pass systems and the true VAV systems.

- **By-Pass Systems.** The by-pass method is where the volume of air is throttled at the terminals, not at the fan. To vary the volume of air in the spaces, the by-pass system bypasses the supply outlets and cycles, or dumps, the excess air into the return air duct rather than actually throttling down the air. This is not considered a true VAV system, but it works adequately for smaller simpler systems.

- **True VAV.** The second method is the true VAV, or "turn down" VAV system. It actually throttles the air down at the terminal boxes rather than by-passing and cycling, and reduces the output at the fan, generally with inlet vanes on centrifugal fans or with variable pitch vane axial fans. Static pressure or constant volume monitoring stations in the main duct monitor the changing air volume and pressure, and via controls, transmits a message to the fan directing it to increase or decrease its flow.

a fan directing it to increase or decrease its flow.

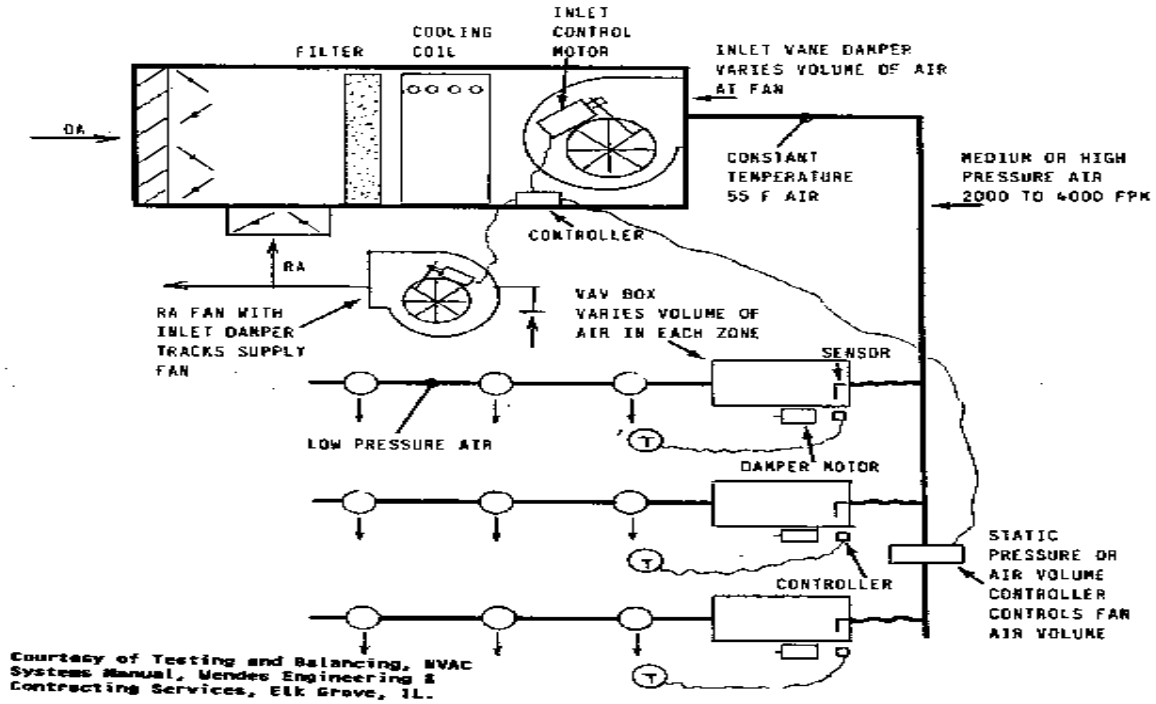


Figure 2, Decreasing and increasing air flow

Methods of varying fan volume. There are a number of different methods of varying the airflow at the fan in VAV systems, including:

- **Inlet Vane Dampers.** The inlet vane dampers are in the intakes of centrifugal fans. Inlet vane dampers change the direction of the air entering the fan and control the volume. By changing the angle of the air entering the fan, the ability of the fan wheel to bite the air progressively lessens. This reduces its air handling capacity and, in turn, reduces its horsepower consumption.

- **Vane Axial Fans.** Vane axial fans with variable pitched blades are another excellent approach. The air handling capacity of a vane axial fan is modulated by controlling the pitch.

- **Variable Pitch Drives.** Automatic variable pitch drives, which change the fan rpm by varying the motor pulley diameter, produce excellent energy savings.

- **Multiple Fans.** Another way to vary the airflow is by placing several fans, one behind the other, and turning them on and off.

- **Variable Frequency Drive.** This is an electronic system that varies the volume of air by varying the speed of the motor.

BASIC TROUBLESHOOTING CHART

CHECK	RESULT	ACTION
Power	No power	Restore power
Wiring Connections	Dirty, loose	Clean and tighten
Damper Linkages	Binding, improper alignment, disconnected, inoperable	Adjust
Thermostat	Inoperative	Calibrate/Replace
Air Flow	Too little	Clean/Replace filters Clean cooling & Heating coil Open/adjust damper (Return air, Fire protection, zone, VAV) Repair ductwork (crushed, holes, size)
Motor	Windings shorted or open	Replace motor
Belt	Broken	Replace
Coil Temperature	Too warm/cool	Clean Check/Adjust/ Replace control valves Clean strainers/ traps Check heating/cooling water source
Motor speed	Too slow/fast	Replace belts Check pulley size/adjustment Check/Repair Variable speed drive

Review Questions
for
Troubleshoot
Correct Malfunction

Question	Answer
1. Central station units can be totally self-contained, with all heating and refrigeration system components as an integral part of an HVAC unit.	a. True b. False
2. One application of a central system is_____.	a. Multiple systems for large areas b. As a secondary source of conditioned air for other systems c. Large areas requiring precision control d. All of the above
3. The basic central station system is an all-air, _____, _____, ventilating and air conditioning system.	a. single-zone, heating, b. single-zone, refrigeration, c. dual -zone, heating, d. low-zone, heating,
4. A coil using cold water for cooling and another using hot water for heating can be substituted for the direct expansion refrigerant coil.	a. True b. False
5. A terminal unit is a device or unit, that is located where the supply duct or duct branch _____ and the air is introduced into the space to be conditioned.	a. terminates b. starts c. splits d. crosses
6. Heating, ventilating, and air conditioning units that are connected to air duct systems, which distribute air to sizable areas of a building, are known as _____.	a. central station HVAC units b. grand central station HVAC units c. central station HVAC ducts d. connection station HVAC units
7. Most HVAC systems in the past, with certain exceptions, have been CONSTANT AIR volume, VARIABLE TEMPERATURE type systems.	a. True b. False
8. As an average, VAV systems run at ____ of the peak load.	a. 70% b. 75% c. 60% d. 100%
9. Zones inside a building located away from the outside walls are called _____.	a. interior zones b. exterior zones c. moderate zones d. comfort zones

Review Questions
for
Troubleshoot
Correct Malfunction

Question	Answer
10. Variable air volume systems are mostly cooling only systems.	a. True b. False
11. One common approach in buildings is to have separate interior and perimeter systems, such as cooling only VAV systems for the interior, and a heating only (or heating cooling) system for the _____.	a. perimeter b. immediate areas c. VAV perimeter. d. outside systems
12. There are two basic methods used in VAV systems: the by-pass systems and the true VAV systems.	a. True b. False
13. The by-pass method is where the volume of air is throttled at the fan, not at the terminal.	a. True b. False
14. A true VAV system actually throttles the air up at the terminal boxes rather than bypassing and cycling, and reduces the output at the fan.	a. True b. False
15. According to the troubleshooting chart, you should check/repair variable speed drive if a belt should break.	a. True b. False
16. According to the troubleshooting chart, you should adjust a motor if the windings have shorted or opened.	a. True b. False
17. According to the troubleshooting chart, you should check/repair variable speed drive of the motor if the airflow is too little.	a. True b. False

TROUBLESHOOT
CORRECT MALFUNCTION

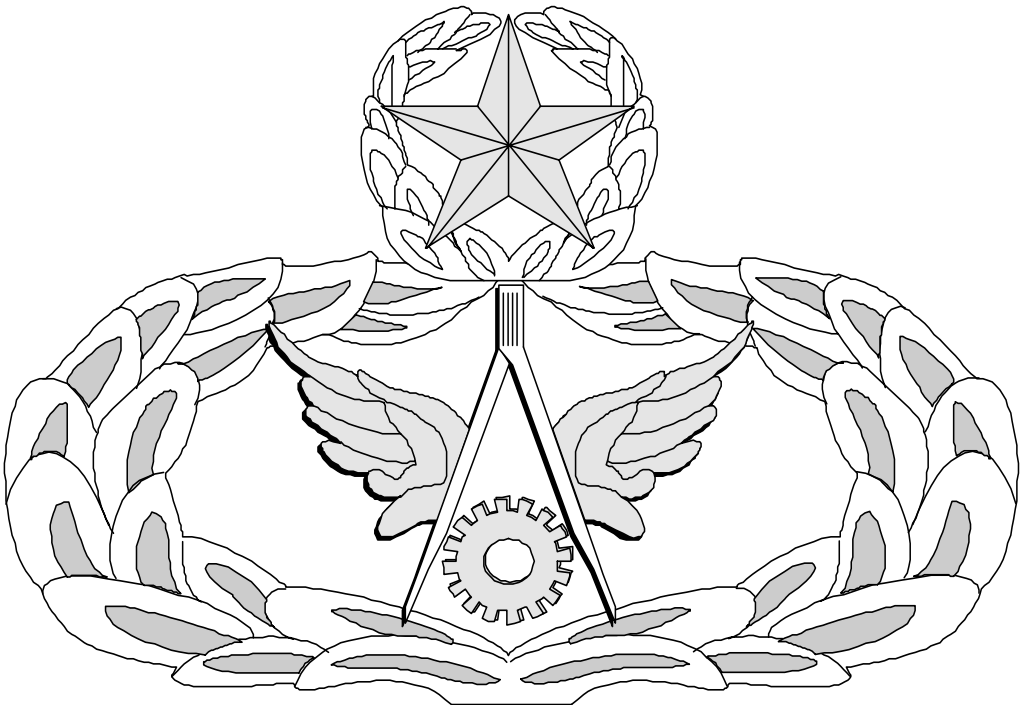
Performance Checklist		
Step	**Yes**	**No**
1. Did trainee successfully perform tasks on Airflow?		
Step 1 - Check filters		
Step 2 - Check coil for cleanliness		
Step 3 - Dampers (Fire, Zone, Return Air, Other)		
Step 4 - Duct work (Crushed, broken, open, blockage)		
Step 5 - Fan direction		
2. Did trainee successfully perform tasks on thermostats?		
Step 1 - Calibrate		
Step 2 - Replace		
3. Did trainee successfully perform tasks on motors?		
Step 1 - Check Belt		
Step 2 - Check power		
Step 3 - Check pulley		
Step 4 - Check Speed control		
4. Did trainee successfully perform tasks on pneumatic controls?		
Step 1 - Check the supply air for the required pressure.		
Step 2 - Use the schematic drawing to trace system operation.		
Step 3 - Isolate the component suspected of failure.		
Step 4 - Check for correct operation, repair or replace as required.		

FEEDBACK: Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.

Air Force Civil Engineer

QUALIFICATION TRAINING PACKAGE (QTP)

REVIEW ANSWER KEY



For

HVAC/REFRIGERATION

(3E1X1)

MODULE 15

HVAC SYSTEMS

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TROUBLESHOOT
CORRECT MALFUNCTION

(3E1X1-15.10.2., 15.10.2.)

Question	Answer
1. Central station units can be totally self-contained, with all heating and refrigeration system components as an integral part of an HVAC unit.	a. True
2. One application of a central system is_____.	a. Multiple systems for large areas
3. The basic central station system is an all-air, _____, _____, ventilating and air conditioning system.	a. single-zone, heating,
4. A coil using cold water for cooling and another using hot water for heating can be substituted for the direct expansion refrigerant coil.	a. True
5. A terminal unit is a device or unit, that is located where the supply duct or duct branch _____ and the air is introduced into the space to be conditioned.	a. terminates
6. Heating, ventilating, and air conditioning units that are connected to air duct systems which distribute air to sizable areas of a building are known as _____.	a. central station HVAC units
7. Most HVAC systems in the past, with certain exceptions, have been CONSTANT AIR volume, VARIABLE TEMPERATURE type systems.	a. True
8. As an average, VAV systems run at ____ of the peak load.	a. 70%
9. Zones inside a building located away from the outside walls are called _____.	a. interior zones
10. Variable air volume systems are mostly cooling only systems.	a. True
11. One common approach in buildings is to have separate interior and perimeter systems, such as cooling only VAV systems for the interior, and a heating only (or heating cooling) system for the _____.	a. perimeter

TROUBLESHOOT
CORRECT MALFUNCTION

(3E1X1-15.10.1., 15.10.2.)

Question	Answer
12. There are two basic methods used in VAV systems: the by-pass systems and the true VAV systems.	a. True
13. The by-pass method is where the volume of air is throttled at the fan, not at the terminal.	a. True
14. A true VAV system actually throttles the air up at the terminal boxes rather than bypassing and cycling, and reduces the output at the fan.	b. False
15. According to the troubleshooting chart, you should check/repair variable speed drive if a belt should break.	b. False
16. According to the troubleshooting chart, you should adjust a motor if the windings have shorted or opened.	b. False
17. According to the troubleshooting chart, you should check/repair variable speed drive of the motor if the airflow is too little.	b. False